SOUTHWESTERN CORN BORER
FLIGHT AND MATING ACTIVITY

by

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INTRODUCTION

The southwestern corn borer, Diatraea grandiosella (Dyar), is the most destructive corn pest in central Kansas. The insect causes reductions in corn yield by tunneling plants and cutting food channels in the larval stage. More importantly, larvae girdle corn plants just before harvest time. The corn plants lodge easily and are extremely difficult to pick up during harvest.

Timing of insecticide applications by the capture of the first adult southwestern corn borer (SWCB) has been used (Henderson and Davis, 1969 and 1970) without a full understanding of the adult population. To fully understand and effectively model and SWCB population a knowledge of all developmental stages is necessary. Basic information on the adult stage is lacking. Studies were conducted during 1976 and 1977 to (1) determine seasonal population trends and relative abundance of adult borers. (2) determine the most effective trap for selective capture of adult SWCB, and (3) determine factors which influence adult capture (time of night flight, trap height, and various environmental conditions).

LITERATURE REVIEW

Trapping Techniques

The most widely used sampling methods for adult Lepidoptera result in relative population estimates (Southwood, 1966). Light traps of varying designs have been used for many years to sample insect populations and have shown the value of long-term use to adequately measure functions of changing populations (Williams, 1940). Of the different available light sources blacklight (ultraviolet spectral range 320 - 380 nm.) has been the most attractive to insects (Frost, 1953; Rolston, 1955; Hendricks et al., 1975, and Glick and Hollingsworth, 1964). Inverted light trap use resulted from studies showing that bare lamps were more attractive to insects than lamps contained within deep-bowl type reflectors (Gui et al., 1942). These traps satisfactorily monitored European corn borer (ECB), *Ostrina nubilalis*, population trends, but standard light traps captured a greater number of individuals (Belton and Kempster, 1963). Showers et al. (1974) concluded that the inverted light trap was a valuable tool for monitoring field populations of ECB. Reflection from the light trap baffles may reduce trap catches (Frost, 1957). Painting baffles reduces reflection and increases capture of some moths (Stahl, 1954). Hartstack et al. (1968) measured light trap efficiency and found that traps attracted large numbers of insects which were not caught.

Other trapping techniques not requiring light as the attractive source have been used to monitor insect populations. Cyclindrical sticky traps have been used for capture of small insects acting much like inert particles. During capture trap efficiency was almost constant in winds from 2 - 10 mph. (Taylor, 1962). Green cloverworm, Plathypena scabra, populations in soybeans were successfully monitored by simple water-pan traps (Myers, 1976). Water-pan traps baited with virgin females were more effective in capturing ECB than similarily baited sticky traps (Showers et al., 1974). Sticky traps, baited with virgin-female SWCB, were used to monitor nightly male flight activity (Langille and Keaster, 1973). Comparisons of baited and standard light traps indicated that baited traps were more effective when population levels were low. However, when populations were high, increased competition for males by feral females caused low catches in the baited traps and a lack of synchrony with the light traps (Showers et al., 1972; Hendricks et al., 1973; and Roach, 1975). Oloumi-Sadeghi et al. (1975) concluded that alternative monitoring systems were important for proper biological interpretation of ECB population data obtained from sex pheromone traps because of the lack of synchrony with light traps. Another problem encountered using pheromone traps was spacing. Pheromone traps for the cabbage looper, Trichoplusia ni, must be spaced 244 m. apart in order to have each trap working independently (Toba et al., 1970). Mc-Laughlin et al. (1975) using colored pheromone traps for

cabbage looper and soybean looper, *Pseudoplusia includens*, determined that traps painted black and international orange collected the most loopers. Sternlicht (1974) saw no significant difference in pheromone trap coloration for *Prays citri* capture.

Time of Flight

Flight activity of many nocturnal insects has been determined by a variety of trapping techniques. Differences in male and female cabbage looper flight activity result from their mating and ovipositional behavior (Shorey, 1964). High noctuid moth activity resulted from female sex pheromone secretion (Graham et al., 1964). Peak period of flight activity varied with the different pyralid moth species (Williams, 1935). Langille and Keaster (1973) determined that peak male SWCB mating activity occurred between 11:00 P.M. and 2:00 A.M. Two peak ECB activity periods occurred between 9:00 and 10:00 P.M. and between 2:00 and 4:00 A.M. (Stewart and Lam, 1969). Huber et al. (1928) ascribed the early evening peak activity to mate seeking and oviposition. He stated that the morning peak served no definite function. Showers et al. (1976) disagreed that early evening activity was oriented towards mating, because sexual activity peaked between 12:00 P.M. and 1:00 A.M. in the tall grass away from the corn field.

Vertical Flight

Determination of vertical insect flight is necessary for optimum trap placement. Vertical flight has been determined by light trap columns, viz., standard light traps placed one on top of another (Ficht and Hienton, 1941; Frost, 1958; Deay et al., 1965; and Stewart and Lam, 1968). Shifting the vertical position of a single trap on a nightly basis was another technique used to determine vertical flight (Ficht et al., 1940; Deay, 1950; and Vojnit and Voight, 1971). Traps placed at the same height as corn plants were more effective for ECB capture than traps placed at higher or lower levels (Ficht et al., 1940; Ficht and Hienton, 1941; Deay, 1950; and Vojnit and Voight, 1971). Frost (1958) concluded that generally, smaller insects were attracted to traps placed at lower levels while larger insects were attracted to traps at all levels.

Environmental Influences

Weather strongly influences insect activity. Daily insect activity is directly dependent on the daily rhythm of the weather (Uvarov, 1931).

Light trap catches can be affected by the lunar phase. ECB capture during the full moon was greatly reduced (Cook, 1961; and Hartstack et al., 1973). Uvarov (1931) and Robinson (1952) reasoned that low light-trap catches during the full moon were caused by negative light influence which resulted in flight inhibition. Dufay (1964) concluded that the full moon did not have a direct affect on the

phototrophism of most nocturnal insects. He attributed reduced collections to the reduced attractiveness of artificial light sources. Gentry and Davis (1973) reported a significant negative correlation of cabbage looper catches when the blacklight trap was used alone. When the blacklight trap was baited with a sex pheromone, bright moonlight made little difference in the catch. Seasonal fluctuations of pink bollworm, Pectinophora gossypiella, and bollworm, Heliothis zea, indicated that flight was synchronized with moon phase and that the highest activity occurred during the new moon (Agree et al., 1972; and Nemec, 1971). Cook (1961) reported little correlation between lunar periodicity and ECB flight activity.

Ability and willingness to fly are dependent on temperature. Flight occurs between lower and upper temperature thresholds (Taylor, 1963). The lower temperature for ECB has been reported as 58-60°F (Carruth and Kerr, 1937; Ficht and Hienton, 1939; and Deay, 1950). A falling temperature, decreasing light, and high relative humidity were required for successful laboratory ECB mating (Sparks, 1963). Showers et al. (1974) reported that nightly drops of 6-12°C after 5:00 P.M. and a temperature plateau of 2 or more consecutive hours with a high relative humidity (70-96%) must usually occur to allow searching and attraction activities of male ECB.

An indication exists of optimum humidity influencing ECB flight activity, but it is not well defined (Cook, 1961).

Activity of various insects was depressed by low humidity (Uvarov, 1931). Callahan (1965) reported that moisture disrupted corn earworm, Heliothis zea, sensing ability. DeRozari et al. (1977) showed that dew significantly affected ECB sexual activities.

Wind seriously affects insect flight (Uvarov, 1931). ECB flies against the wind and approaches light traps from the leeward side (Deay, 1950). ECB flight was not affected by wind velocities up to 17 mph, but winds up to 10 mph reduced the attractiveness of light traps (Cook, 1961).

METHODS AND MATERIALS

Trapping Study

During 1976 and 1977 three corn fields in Stafford County, Kansas were selected for adult SWCB sampling. Fields were furrow irrigated and had 110V AC power outlets. All traps were placed in the fields by July 10 during both years. All traps except the standard light trap were replicated 3 times in each field using a completely randomized design. Because of a limited number of standard light traps only one was placed in each field. To prevent border effects all traps were placed at least 91.4 m in each field and were spaced 27.4 m apart. To prevent trap interference all vegetation within a 1.2 m radius was removed from each trap site. During 1976 the attractive source of all traps was placed 1.2-1.5 m above ground level. Noting that most of the SWCB eggs were laid at a lower level during 1976, the attractive source during 1977 was lowered to 0.9 m.

During 1976 twelve different trap types were evaluated: 9 cyclindrical sticky traps, the inverted light trap, the water pan trap, and the standard light trap. The cyclindrical sticky traps consisted of 0.95 l. cartons painted 9 different colors (red, white, blue, black, purple, orange, silver, fluorescent orange, and fluorescent green). Tack-Trap® was applied over the painted surface. Each trap was

wrapped with plastic wrap for ease of transport in the fields. The water pan trap consisted of 2 circular galvanized pans (39.4 cm diam by 12.7 cm deep). The bottom pan was nailed to a post (10.2 cm by 10.2 cm by 1.8 m). The second pan was placed inside the first pan and filled 1/2 full of water. Chiffon® detergent was added as a wetting agent. The inverted light trap components were (1) a 15-watt incandescent-light bulb, (2) a funnel with a 35.6 cm opening and a 2.5 cm aperature, (3) a one 0.47 l wide mouth jar glued to the funnel top, and (4) a 5.1 cm by 7.6 cm dichlorvos strip (Shell No-Pest® Strip) which was replaced every 10 days. The standard light trap was a commercially manufactured light trap (Harding et al., 1966). One dichlorvos strip was used as the killing agent and was replaced every 14 days.

During 1976 the standard light trap was sampled daily and the number and sex of all SWCB moths was recorded. Light trap variance was determined by moving the 3 standard light traps into each field (randomly selected) for 3 consecutive sampling periods (Field 1: July 30 to August 1, Field 2: August 11-13, and Field 3: August 5-7). All other traps were sampled every 3 days and the number and sex of SWCB moths was recorded. Sticky traps were replaced at 3 day intervals. Corn height and moon phase during the peak flight period were recorded. The last sampling date was August 13. The percentage infestation of second-generation larvae was determined by randomly selecting 10 samples (10 plants/sample) from each corn field.

During 1977 four trap types were evaluated: the standard light trap, the inverted light trap, a water pan trap baited with virgin-female SWCB, and an orange water trap. Calcium cyanide was used as the killing agent in the standard light trap and inverted light trap, and was replaced daily. Several modifications were made to the inverted light trap. Modifications were (1) a smaller opening (27.9 cm), (2) a larger funnel aperature (3.8 cm), (3) a 75-watt incandescent blacklight bulb (Litebug®), (4) a larger catch container (2.4 l), and (5) the funnel inter-surface was painted fluorescent orange. The water pan trap used during 1976 was baited with virgin-female SWCB suspended 7.6 cm above the water surface in a small cage. The cage was attached to the upper lip of the water pan trap with a wire frame. The cage was cyclindrical (5.1 cm by 7.6 cm) using 0.3 cm wire mesh. The cage bottom was a petri plate held in place by a rubber band. Between July 10 and 15 virgin females for the baited trap came from the SWCB colony at Kansas State University, Manhattan, Kansas. Thereafter female pupae were field collected. When available newly emerged virgin females were replaced daily. The water pan trap used in 1977 was the same as the trap used in 1976 except it was painted orange. All traps were sampled daily and SWCB numbers and sex were recorded. The last sample dates were July 25 for the baited water-pan trap and August 23 for the other traps.

To determine the time of nightly flight activity a single standard light trap was sampled at 1 hour intervals

during the nocturnal period on July 21, 25, August 15, and 22, 1977. The number and sex of captured SWCB moths were recorded for each time interval.

The SWCB sex ratio was determined by sexing 98 field-collected first-generation pupae. The percentage first generation larval infestation was determined by randomly selecting 4 samples (25 corn plants/sample) from each field. On July 27, 1977 each field was sampled for SWCB eggs. Random samples (4 samples/field and 5 plants/sample) were taken from each field. After harvest, the percentage second-generation larval infestation was determined by randomly sampling in each field (10 samples/field and 10 plants/sample).

Ovipositional Study

During 1977 80 corn plants (16 five-plant samples) were marked at Sandyland Experiment Station, St. John, Kansas. Between July 10 and 20 eggs were counted at 2 day intervals, and after July 20 eggs were counted at 3 day intervals. Egg masses were circled using a felt-tipped pen containing permanent ink. The number of eggs and the oviposition date were recorded. On July 28, after completion of major ovipositional activity, the height of all marked egg masses was determined at 0.3 m intervals.

Vertical Flight Study

During 1977 vertical flight was determined in 2 fields using light trap colums on the evenings of July 21, 24, and

25. The light trap column consisted of 4 (0.9 m high) light traps suspended one on top of the other with the bottom trap at ground level. Traps were suspended under a tripod (4 m tall). Trap construction consisted of (1) a modified strip light with a 15-watt white fluorescent bulb, (2) a funnel with a 35.6 cm opening and a 5.1 cm aperature, (3) a 30-lb fruit can with a hole (25.4 cm diam) cut in the lid, and (4) a base board (25.4 cm by 25.4 cm). All four components were then tied together in a standard-light trap configuration using nylon twine. Baffles were not used. At each trap site all vegetation within a 3-m radius was removed to prevent trap interference. The number and sex of captured borers were recorded for each trap height (0.6-0.9 m, 1.5-1.8 m, 2.4-2.7 m, and 3.4 - 3.7 m). Corn height was measured in each field on July 27.

RESULTS AND DISCUSSION

Seasonal Abundance

Seasonal occurrence of male and female SWCB was determined during 1976 (fig. 1) and 1977 (fig. 2) using the number of SWCB captured in the 3 standard light traps. Because the traps were separated 7-10 miles, the population trends of the males (fig. 3) and females (fig. 4) in the 3 fields were compared. Flight activity (initiation, peak, and termination of major activity) was approximately the same in each field. Because population trends in the 3 fields were closely related, a single standard light trap probably could be used to monitor the SWCB population trends within a small area (7-10 mile radius of the trap).

During 1976 ca. 5,000 SWCB adults were captured. The first male moth was captured on July 16 (fig. 1) and the first female on July 18. The last sample date was August 13, but a few SWCB adults were still active. Major flight activity began on July 22 (both sexes). Major female flight ended on August 3 and male flight on August 5. There were two periods of high flight activity, a minor peak on July 27 and a major peak on July 31.

During 1977 ca. 45,000 SWCB adults were captured. Because moths were active when the traps were placed in the fields on July 9 (fig. 2), the initiation of first-generation

Figure 1. Seasonal abundance of male and female SWCB during 1976 at Stafford Co., KS.

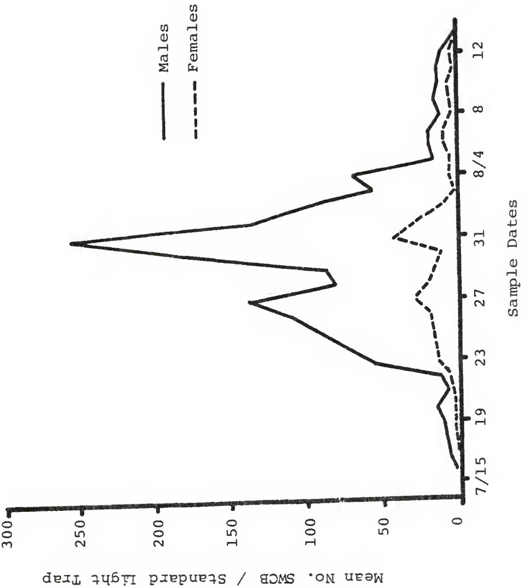

Males
Females
Mean No. SWCB / Standard Light Trap
0
50
100
150
200
250
300
Sample Dates
7/15
19
23
27
31
8/4
8
12

Figure 2. Seasonal abundance of male and female SWCB during 1977 at Stafford Co., KS.

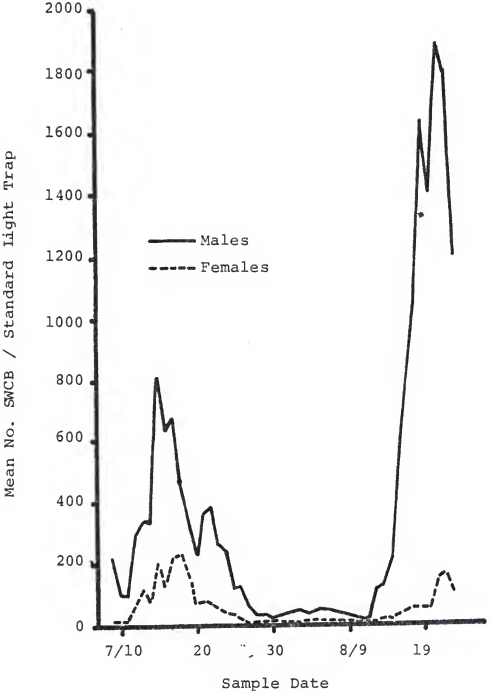

Mean No. SWCB / Standard Light Trap
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Males
Females
7/10
20
30
8/9
19
Sample Date

Figure 3. Comparison of male SWCB population trends in three fields located in Stafford Co., KS. during 1977.

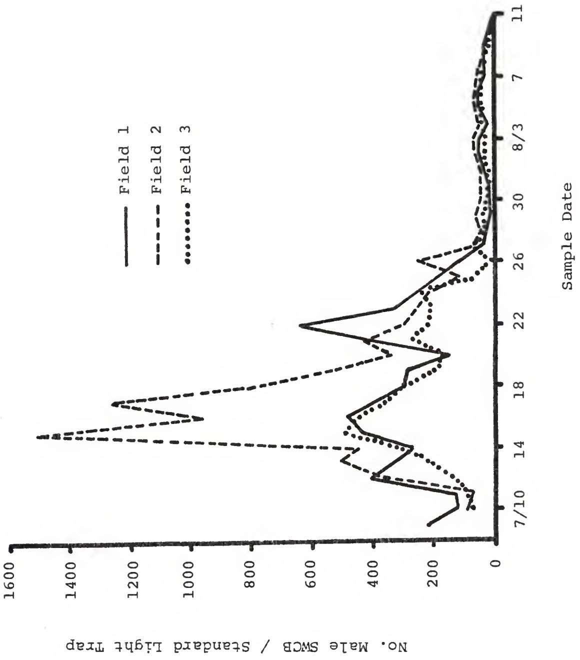
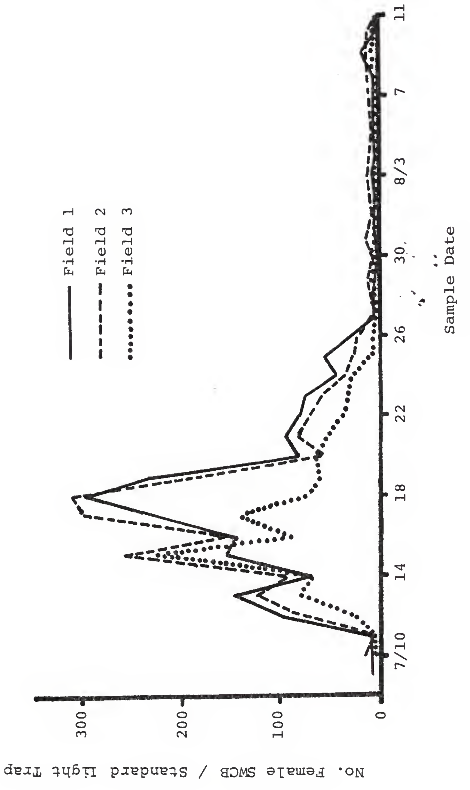

Field 1
Field 2
Field 3
1600
1400
1200
1000
800
600
400
200
0
7/10
14
18
22
26
30
8/3
7
11
Sample Date
No. Male SWCB / Standard Light Trap

Figure 4. Comparison of female SWCB population trends in three fields located in Stafford Co., KS. during 1977.


Field 1
Field 2
Field 3
No. Female SWCB / Standard Light Trap
300
200
100
0
7/10
14
18
22
26
30
8/3
7
11
Sample Date

flight was not determined. The major flight activity of the first-generation was between July 11 and July 27. During 1977 the major flight activity period occurred approximately two weeks earlier than during 1976. Whitworth and Poston (unpublished data) observed that the thermal-unit accumulation for a SWCB developmental model was more rapid during 1977 than 1976 and accounted for the two week shift in the major flight activity. The peak flight activity of first-generation males was between July 15 and July 17. The peak flight activity of first-generation females was on July 15, 17, and 18. Between July 27 and August 13 there was low flight activity which probably represented the end of first-generation flight and the beginning of second-generation flight. Major flight activity of the second generation was from August 15 to at least August 23. On the last sample date (August 23) a large number of moths were still active.

During 1977, a survey of 98 first-generation pupae collected from the field yielded 46 males and 52 females. This indicated that the sex ratio was ca. 1:1. The standard light trap had a definite trap bias for male capture (table 1). During 1976 the standard light trap collected 5.8 males for every female. During 1977 the trap captured 3.88 first-generation males for every female. However, 17.92 second-generation males were captured for every female.

Table 1. Standard light trap bias for males during 1976 and 1977 at Stafford Co., KS.

Year	Generation	No. males	No. females	Sex Ratio[a] (males/females)
1976	1st	4,257	730	5.83
1977	1st	19,058	4,917	3.88
	2nd	19,985	1,115	17.92

[a]Averaged over collections from the designated time period.

<u>Ovipositional Studies</u>

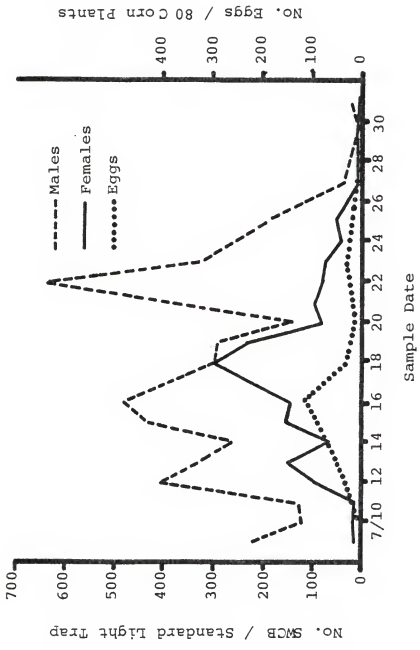
During 1977 the SWCB oviposition rate in the field was compared to the SWCB light trap catch (fig. 5). On July 10 the first newly laid egg was observed in the field. After August 5 no new eggs were observed. The major ovipositional period occurred between July 11 and 27 with peak activity occurring between July 15 and 16. Peak female capture occurred ca. 2 days later on July 18. This indicated that peak female capture did not represent the time of peak oviposition.

Adequate sample size for eggs and egg masses were determined by two methods using the oviposition rate data. The first method was a technique developed by Iwao and Kuno (1968), which based the sample size on the mean crowding of the population. The mean crowding ($\overset{*}{m}$) was derived from the formula: $\overset{*}{m} = \alpha + \beta m$, where m was the mean density, α was the y-intercept and β was the slope. Linear regression was used to estimate α and β for the variables eggs ($\hat{\alpha} = 1.0$, $\hat{\beta} = 0.81$) and egg masses ($\hat{\alpha} = 1.52$, $\hat{\beta} = 0.55$). The sample size (q) was calculated from the formula:

$$q = \frac{t^2}{D^2} \left(\frac{\hat{\alpha} + 1}{\bar{x}} + \hat{\beta} - 1 \right),$$

where t = student's t ($P < 0.05$) with q-1 degrees of freedom, D = desired precision (.1 or .25), and $\bar{x}$ = the mean. Adequate sample sizes for eggs (fig. 6) and egg masses (fig. 7) were determined at the 10% and 25% precision levels. The 16 five-plant samples required egg counts with a sample mean of at

Figure 5. Comparison of first-generation male and female SWCB catches in a standard light trap to the abundance of SWCB eggs sampled in the field that was located by Sandyland Exp. Stn., St. John, KS. during 1977.



No. SWCB / Standard Light Trap
0
100
200
300
400
500
600
700
No. Eggs / 80 Corn Plants
0
100
200
300
400
Males
Females
Eggs
7/10
12
14
16
18
20
22
24
26
28
30
Sample Date

Figure 6. Adequate sample size for mean number of second-generation SWCB egg samples necessary to achieve 10% and 25% precision levels.

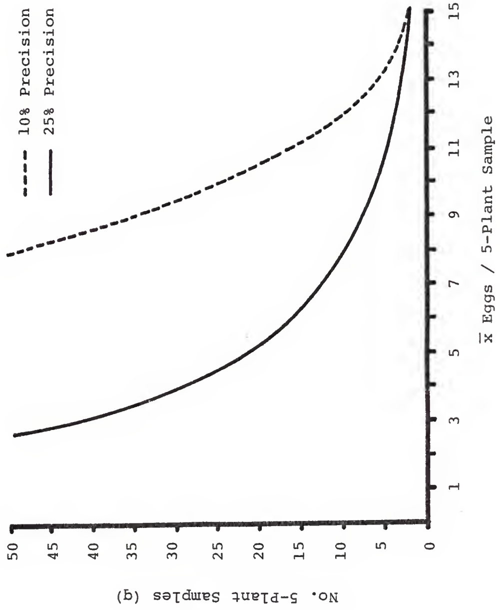
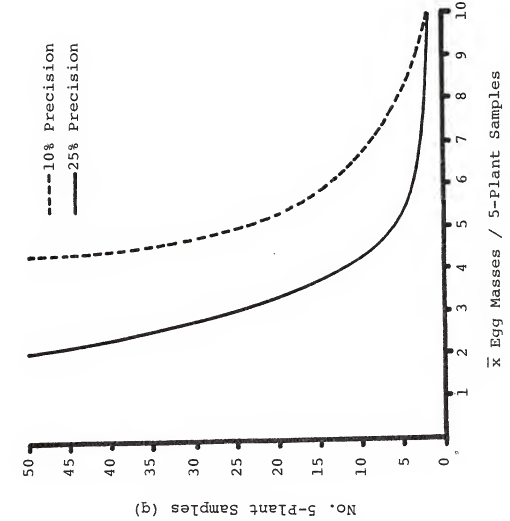

10% Precision
25% Precision
No. 5-Plant Samples (q)
50
45
40
35
30
25
20
15
10
5
0
1
3
5
7
9
11
13
15
$\bar{x}$ Eggs / 5-Plant Sample

Figure 7. Adequate sample size for mean number of second-generation SWCB egg mass samples necessary to achieve 10% and 25% precision levels.


10% Precision
25% Precision
No. 5-Plant Samples (q)
0
5
10
15
20
25
30
35
40
45
50
1
2
3
4
5
6
7
8
9
10
$\bar{x}$ Egg Masses / 5-Plant Samples

least 6.0 (D = .25) or 1.11 (D = .1) eggs/sample to be considered adequate (fig. 6). The egg mass counts required sample means of 3.7 (D = .25) or 5.8 (D = .1) egg masses/sample to be considered adequate (fig. 7). On July 14 and 16 eggs and egg masses were adequately sampled at the 25% precision level. Only on July 16 were eggs and egg masses adequately sampled at the 10% level (tables 2 and 3).

Adequate sample size was also determined by the use of relative variation (RV). RV determined the sample variability, where RV = $(SE/\bar{x})$ 100. A RV value of ca. 25% is sufficient for extensive studies, but a value of ca. 10% is required for intensive studies (Southwood, 1966). None of the egg or egg mass samples had RV values less than 10% (tables 2 and 3). Eggs were adequately sampled (RV < 25%) on July 14, 16, and 23 (table 2). Egg masses were adequately sampled on July 12, 14, 16, 18, and 23 (table 3). Because more dates were adequately sampled (RV < 25%) using the RV method, Iwao and Kuno's technique was a more critical measure of sample size. Each five-plant sample required ca. 10 minutes to process.

Dispersion patterns of SWCB eggs and egg masses were also determined from the oviposition rate data. The index of dispersion $(s^2/\bar{x})$ and the chi-square test were used to determine the sample distributions. The variance to mean ratio will approximate unity if there is agreement with a Poisson distribution. The chi-square test was used to determine the goodness-of-fit of observed data with either Poisson or negative binomial distributions. The index of dispersion for the

Table 2. Means, variance, relative variation, and distribution of SWCB egg counts between July 10 and August 5, 1977.

				Index of Dispersion		Goodness-of-Fit
Date	$\bar{x}$	s^2	RV	$s^2/\bar{x}$	Distribution	Distribution
July 10	0.063	0.063	100	1.00	Poisson	Poisson
12	3.75	20.98	30.5	5.56	Neg. Binomial	Neg. Binomial
14	8.75	17.89	12.1	2.04	Neg. Binomial	Neg. Binomial & Poisson
16	14.50	87.61	16.1	6.04	Neg. Binomial	Neg. Binomial & Poisson
18	3.81	20.07	29.4	5.27	Neg. Binomial	Neg. Binomial
20	1.31	3.53	35.9	2.69	Neg. Binomial	Neg. Binomial
23	5.63	22.37	21.0	3.97	Neg. Binomial	Neg. Binomial & Poisson
27	1.56	4.41	33.7	2.83	Neg. Binomial	Neg. Binomial
30	0.50	0.79	44.5	1.58	Poisson	Neg. Binomial & Poisson
Aug. 2	0.063	0.063	100	1.00	Poisson	Poisson
5	0.31	0.76	70.2	2.44	Neg. Binomial	Neg. Binomial & Poisson

Table 3. Means, variance, relative variation, and distribution of SWCB egg mass counts between July 10 and August 5, 1977.

				Index of Dispersion		Goodness-of-Fit
Date	$\bar{x}$	s^2	RV	$s^2/\bar{x}$	Distribution	Distribution
July 10	0.063	0.063	100.0	1.00	Poisson	Poisson
12	1.56	2.66	26.1	1.71	Poisson	Poisson & Neg. Binomial
14	4.00	4.54	13.3	1.14	Poisson	Poisson & Neg. Binomial
16	6.31	13.69	14.7	2.17	Neg. Binomial	Poisson & Neg. Binomial
18	1.44	2.07	24.5	1.44	Poisson	Poisson & Neg. Binomial
20	0.69	1.30	41.3	1.88	Neg. Binomial	Poisson & Neg. Binomial
23	2.44	3.46	19.1	1.42	Poisson	Poisson & Neg. Binomial
27	0.81	0.96	30.3	1.19	Poisson	Poisson & Neg. Binomial
30	0.38	0.52	47.4	1.37	Poisson	Poisson & Neg. Binomial
Aug. 2	0.063	0.063	100.0	1.00	Poisson	Poisson
5	0.19	0.29	71.1	1.53	Poisson	Poisson & Neg. Binomial

majority of the egg masses indicated Poisson distributions (table 3). On July 16 and 20 the egg mass samples fit the negative binomial distribution, but the chi-square test indicated that the samples were adequately described by the Poisson distribution. Using the chi-square test both the Poisson and negative binomial distributions adequately described egg mass samples except on July 10 and August 2 when the RV values were very high. Because the egg samples did not differ from the Poisson distributions (index of dispersion and chi-square test), egg masses were assumed randomly dispersed. The index of dispersion indicated that most of the egg samples had negative binomial distributions (table 2). The egg samples taken on July 10, 30, and August 2 had Poisson distributions, but they had high RV values. The majority of the egg samples were adequately described by the negative binomial distribution using the chi-square test. Because the egg samples were adequately described by the negative binomial distribution, eggs were assumed to be aggregated. Each egg mass had between 1 and 7 eggs with a mode of 2 eggs/mass. This large variation in number of eggs per egg mass probably accounts for the aggregated dispersion of the eggs.

Comparison of Field Infestations to Seasonal Abundance

In each of the three fields standard light trap catches were compared to the resulting infestations of second-generation eggs and larvae (table 4). Field 1 was not the same field during 1976 and 1977, but fields 2 and 3 were the same for both years. In fields 2 and 3 there was no significant ($P < 0.05$) change in the larval infestations from 1976 to 1977. The percentage larval infestation in field 2 was 86% during 1976 and 81% during 1977. In field 3 it was 57% during 1976 and 63% during 1977. In 1976 and 1977 female catches were ca. 75% greater in the fields with higher larval infestations. During 1977 egg counts and larval infestations were closely related. The number of eggs in fields 1 and 2 was 27.6% greater than in field 3, and the resulting larval infestations in fields 1 and 2 were 23% greater than in field 3.

During 1977 the magnitude of the SWCB adult catches was much greater than the 1976 adult catches (fig. 8). Peak SWCB flight in 1977 occurred ca. two weeks earlier than in 1976. The shift was attributed to warmer spring temperatures during 1977. The lunar phase during 1976 peak flight was a full moon. The lunar phase during 1977 was a new moon. Seasonal fluctuations of the pink bollworm and bollworm were synchronized with the moon phase (Agree et al. 1972; and Nemec, 1971). The two week shift in the SWCB development indicated that its development was not synchronized with the moon phase. Lara et al., (1974) recorded larger Lepidoptera catches during the

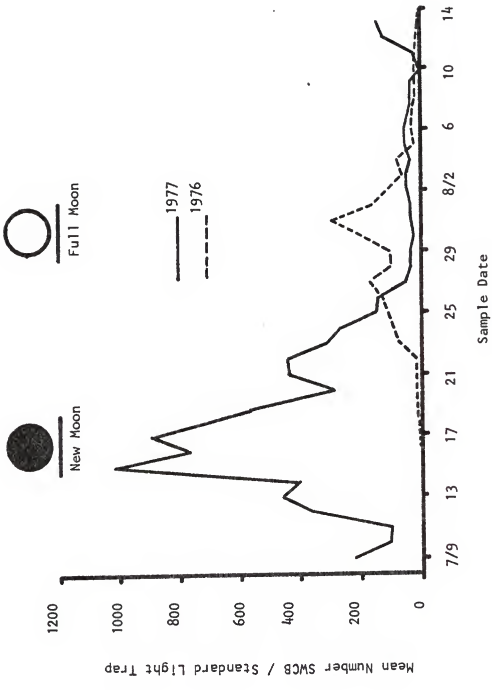
Table 4. SWCB comparisons of field infestations to seasonal abundance.

Year	Field[b]	No. Females[a]	No. Eggs/ 20 Plants[a]	2nd-Gen. Larval Infestation (%)[a]
1976	1	192 a	-	60 a
	2	305 b	-	86 b
	3	170 a	-	57 a
1977	1	1863 c	114 a	91 b
	2	1981 c	126 a	81 b
	3	1052 d	94 b	63 a

[a]Numbers in the same column followed by the same letter did not differ significantly ($P < 0.05$) using Duncan's New Multiple Range Test.

[b]Field 1 was not the same for both 1976 and 1977.

Figure 8. Affect of moon phase on seasonal abundance of first generation SWCB during 1976 and 1977 at Stafford Co., KS.


New Moon
Full Moon
1977
1976
Mean Number SWCB / Standard Light Trap
0
200
400
600
800
1000
1200
7/9
13
17
21
25
29
8/2
6
10
14
Sample Date

new moon phase than other times during the lunar month. Dufay (1964) attributed the reduced moth catches during the full moon to the decreased attractiveness of artificial light that was caused by moonlight. During 1977 female catches in fields 2 and 3 were ca. 638% greater than the 1976 female catches (table 4), but the resulting second-generation larval infestations did not change in either field 2 or 3. Hence, the larger female catches during 1977 did not represent a larger adult population, but may have reflected the influence of the lunar phase on light trap catches.

Time of Flight

Changes in male and female flight activity occurred during the nocturnal period (table 5). High male and low female activity indicates mating activity for Lepidoptera (Chapman, 1971). Between 1:01 and 2:00 A.M. significantly ($P < 0.05$) high male and low female activity occurred indicating SWCB mating. This agrees with observations of Langille and Keaster (1973). They determined that peak mating activity occurred between 11:00 P.M. and 2:00 A.M. based on the number of males attracted to sticky traps baited with virgin-female SWCB. Male activity between 12:01 and 1:00 A.M. was highly variable during the four nights that this study was conducted. This probably indicated the time when the males began seeking females. Between 3:01 and 5:00 A.M. significantly ($P < 0.05$) high SWCB female activity occurred. This probably represented the period of major ovipositional activity. Shorey (1964) observed that female cabbage loopers flew actively while ovipositing, but did not fly when mating occurred.

Table 5. Time of flight activity for first-generation male and female SWCB.

Time	Males[a] $\bar{x}$	Males[a] % Total	Females[a] $\bar{x}$	Females[a] % Total
9:01 - 10:00 P.M.	6.0 a	0.7 a	4.0 a	4.3 a
10:01 - 11:00 P.M.	14.8 a	1.8 a	8.8 ab	9.4 ab
11:01 - 12:00 P.M.	93.8 a	11.1 a	11.0 abc	11.8 abc
12:01 - 1:00 A.M.	179.8 ab	21.2 ab	8.3 ab	8.9 ab
1:01 - 2:00 A.M.	299.3 b	35.4 b	4.5 a	4.8 a
2.01 - 3:00 A.M.	98.8 a	11.7 a	10.0 ab	10.7 ab
3:01 - 4:00 A.M.	70.5 a	8.3 a	19.5 c	20.9 c
4:01 - 5:00 A.M.	56.8 a	6.7 a	17.8 bc	19.0 bc
5:01 - 6:00 A.M.	26.8 a	3.2 a	9.5 ab	10.2 ab

[a]Numbers followed by the same letter in the same column did not differ significantly ($P < 0.05$) using Duncan's New Multiple Range Test.

<u>Vertical Flight</u>

During 1977 the vertical flight of SWCB was determined by light trap columns and the height of egg oviposition (table 6). Significantly ($P < 0.05$) more SWCB adults were collected at the lowest trap height (0.06-0.89 m). Very few adults were captured in the upper two traps (2.40-2.69 m, and 3.30-3.59 m). During the study the average corn height was 2.15 m. Female flight activity was closely related to the height that eggs were oviposited. The highest percentage of eggs were laid on corn between 0.30 and 1.19 m. Agreement between female catches in the light trap column and the height of egg oviposition indicated that female flight was most frequent in the lower portion of the corn plants.

During 1977 corn height was observed as a major factor affecting male capture in standard light traps. Plants in fields 1 and 2 were 2.15 and 1.93 m tall, respectively (table 7). In the two fields female population densities were similar (fig. 9). As previously stated, female activity was the greatest in the lower portion of the corn plants where the foliage was the most dense. Thus, females should not be greatly affected by corn height. Because female catches and egg counts did not differ significantly ($P < 0.05$) in the two fields (table 7), adult population densities were probably equal. In the same two fields male trap catches were not of similar magnitude (fig. 10). Significantly ($P < 0.05$) more males were captured in the shorter corn (table 7). Langille and Keaster (1973) observed in corn fields that male flight

Table 6. Height at which second-generation SWCB eggs were oviposited compared to first-generation adult SWCB catches at different heights in light trap columns.

		Light Trap Column	
Height (m)	Total Eggs (%)	Males (%)	Females (%)
0.00-0.29	4.1 a	-	-
0.30-0.59	22.0 b	-	-
0.60-0.89	33.6 c	84.4 a	82.0 a
0.90-1.19	30.7 bc	-	-
1.20-1.49	6.6 a	-	-
1.50-1.79	2.9 a	13.0 b	12.4 b
1.80-2.09	-	-	-
2.10-2.39	-	-	-
2.40-2.69	-	1.9 c	4.5 c
2.70-2.99	-	-	-
3.00-3.29	-	-	-
3.30-3.59	-	0.8 c	1.1 c

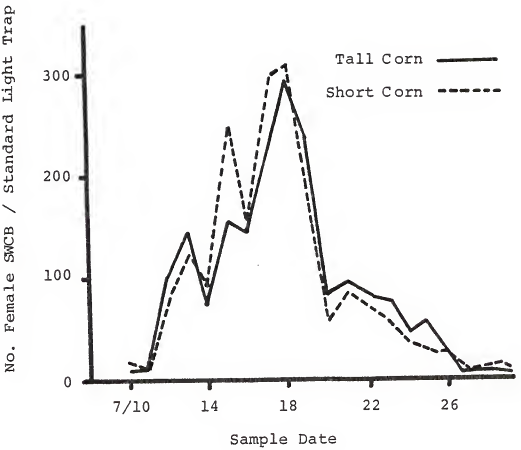
[a]Numbers followed by the same letter did not differ significantly ($P < 0.05$) using Duncan's New Multiple Range Test.

Table 7. The influence of corn height on first-generation adult SWCB trap catch.[a]

Field	$\bar{x}$ corn ht. (m)	Males	Females	Eggs	Sex Ratio (Males/Females)
1	2.15 a	5215 a	1863 a	114 a	2.80 a
2	1.93 b	8572 b	1981 a	126 a	4.33 b

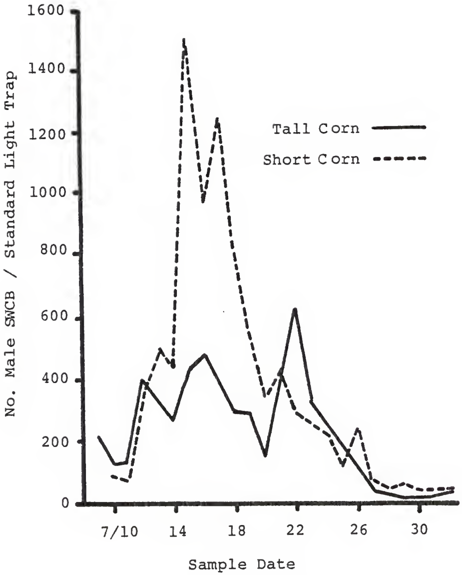
[a]Numbers followed by the same letter did not differ significantly ($P < 0.05$) using Analysis of Variance.

Figure 9. The affect of corn height on the capture of first-generation female SWCB during 1977.



No. Female SWCB / Standard Light Trap
300
200
100
0
Tall Corn
Short Corn
7/10
14
18
22
26
Sample Date

Figure 10. The affect of corn height on the capture of first-generation male SWCB during 1977.


1600
1400
1200
1000
800
600
400
200
0
No. Male SWCB / Standard Light Trap
Tall Corn
Short Corn
7/10
14
18
22
26
30
Sample Date

activity was most frequent at the tassel level. They did not observe females at this height. The corn in field 1 was much taller than the standard light trap, and the corn in field 2 was ca. the same height as the standard light trap. Because SWCB males fly at the tassel level, a larger effective trap radius in the shorter corn probably accounts for the greater male catches.

Trap Evaluations

During 1976 the only trap type that effectively captured SWCB adults was the standard light trap (table 8). The light trap captured 4,987 adults, but it had a large bias for male capture. The light trap was used as the standard for monitoring seasonal population trends. Other traps were not effective for adult capture. Because very low numbers of adults were captured using the sticky traps, color preference was not determined. Results from the vertical flight studies conducted during 1977 indicated that the low catches were partly attributable to trap height (1.2-1.5 m) during 1976. Taylor (1962) treated insects captured on the sticky traps as if they were inert particles. However, SWCB are active fliers and can avoid these traps. Low catches in the inverted light trap probably resulted from (1) trap design, (2) height of trap placement, and (3) incandescent light source. Rolston (1955) observed that SWCB were not strongly attracted to light from incandescent bulbs.

During 1977 all traps except the orange water pan trap were more effective in capturing SWCB adults (table 9). The orange water pan trap was not an effective trapping technique because it worked sporatically and captured only a few adults. During the first-generation flight 23,975 adults were captured in the standard light traps. The time required to process each daily sample was between 0.5 and 2 h depending on the sample size. Because the SWCB were the most prominent insects captured in the inverted light traps and were relatively few

Table 8. Trap comparisons for first-generation SWCB capture during 1976 at Stafford Co., KS.

Trap	Male	Female	Total
Standard light	4,257	730	4,987
Inverted light	o	0	0
Water pan	1	0	1
Sticky (colored)	8	5	13
red	1	1	2
white	0	1	1
black	1	0	1
silver	1	0	1
orange	1	2	3
purple	0	0	0
blue	0	0	0
fluor. orange	1	0	1
fluor. green	4	0	4

Table 9. Trap comparisons for first-generation SWCB capture during 1977 at Stafford Co., KS.

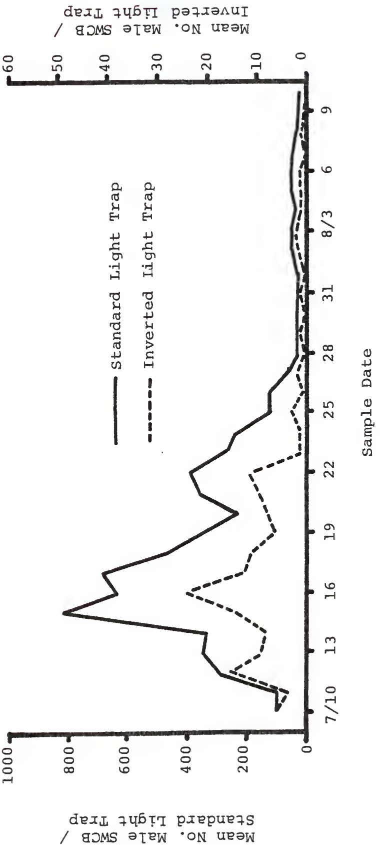
Trap	Male	Female	Total
Standard light	19,058	4,917	23,975
	16,546[a]	-	-
Inverted light	510	96	606
Water pan baited with virgin females	13,297[a]	-	13,297
Orange water pan	6	13	19

[a]Number of males captured between July 10 and July 25.

in numbers, the inverted light trap samples were processed in only 1-2 minutes. Belton and Kempster (1963) stated that the inverted light trap monitored ECB populations, but fewer ECB were captured in it than in the standard light trap. Similar results were obtained when comparing the standard light trap catches of SWCB to inverted light trap catches (figs. 11 and 12). A disadvantage of the inverted light trap was its low effectiveness for capturing adults, especially females, when flight activity was low (fig. 12).

The water pan trap baited with virgin-female SWCB captured 13,297 males and no females between July 10 and 25, 1977 (table 9). During the same period, the standard light trap captured 16,546 males. However, there was a lack of synchrony between the population trends as determined by the light traps and the baited water-pan traps (fig. 13). During low population levels, indicated by the light trap, the baited water-pan trap captured more males than the light trap. During periods of high male activity baited traps collected fewer males than light traps. When the populations increased, competition for males by feral females probably caused a reduction of males captured in the baited water-pan trap. Females were ca. 3.5 days old when they were captured in the light traps (Part II). Thus, the high female population that interacted with the baited water-pan trap was evident several days after low male capture in the baited water-pan trap. A similar lack of synchrony between phermone traps and light traps had been reported for ECB (Oloumi-Sadeghi et al., 1975).

Figure 11. Comparison of first-generation male SWCB population trends as determined by the standard light trap and the inverted light trap during 1977 at Stafford Co., KS.



Mean No. Male SWCB / Inverted Light Trap
60
50
40
30
20
10
0
Standard Light Trap
Inverted Light Trap
Mean No. Male SWCB / Standard Light Trap
1000
800
600
400
200
0
7/10
13
16
19
22
25
28
31
8/3
6
9
Sample Date

Figure 12. Comparison of first-generation female SWCB population trends as determined by the standard light trap during 1977 at Stafford Co., KS.

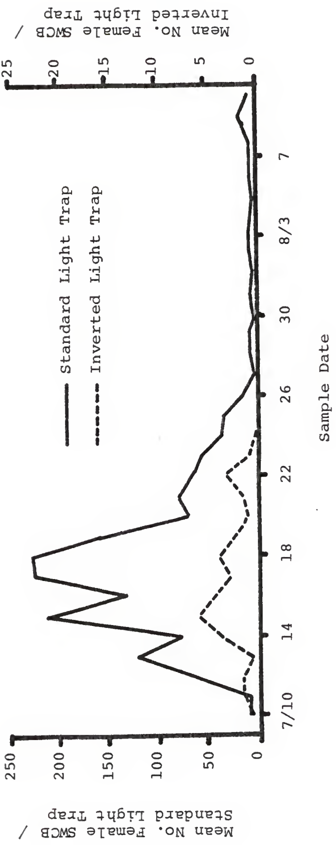
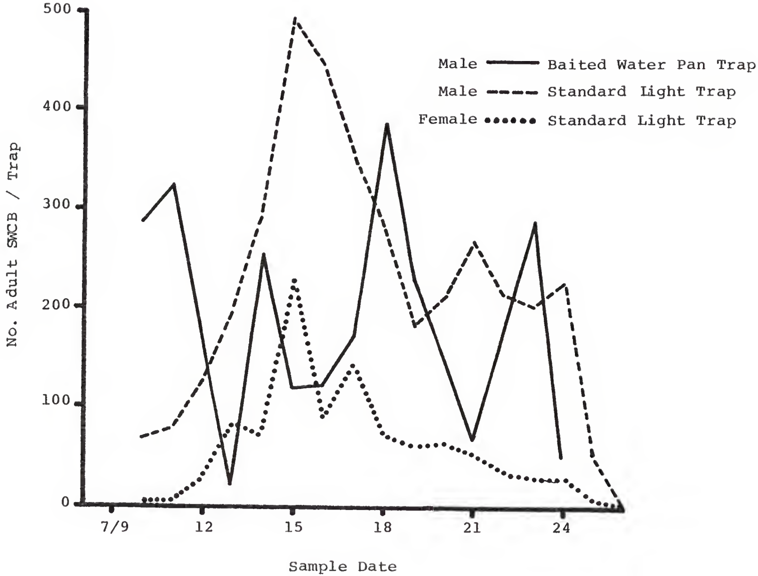

Mean No. Female SWCB /
Inverted Light Trap
0
5
10
15
20
25
Standard Light Trap
Inverted Light Trap
7/10
14
18
22
26
30
8/3
7
Sample Date
0
50
100
150
200
250
Mean No. Female SWCB /
Standard Light Trap

Figure 13. Comparison of SWCB seasonal trends showing lack of synchrony between the standard light trap and the water pan trap baited with virgin-female SWCB during 1977.


500
400
300
200
100
0
No. Adult SWCB / Trap
7/9
12
15
18
21
24
Sample Date
Male Baited Water Pan Trap
Male Standard Light Trap
Female Standard Light Trap

PART II.

Southwestern Corn Borer Mating Activity and Female Reproductive Status

INTRODUCTION

During 1976 and 1977 three insecticide applications for control of second-generation SWCB larvae were timed to the capture of the first first-generation adult. The standard light trap was used to capture the first adult and to monitor populations of the first-generation adult SWCB. However, the relation between adult capture, mating, and ovipositional was not known. To increase the effectiveness of the insecticide applications a more thorough knowledge of the relationship is necessary. Also, a light trap bias for male SWCB capture was observed (Part I). Studies were conducted during 1977 to (1) determine the effect of mating on SWCB capture in light traps, (2) determine the relationship between female flight activity, as determined by the standard light trap, and ovipositional activity, and (3) determine the cause of the light trap bias for male capture.

LITERATURE REVIEW

Female Reproductive Classification

Spermatophore presence or absence is an indication of female ECB mating occurrence. Mated individuals had spermatophores and fertile eggs, whereas unmated females lacked spermatophores and had nonfertile eggs (Pesho, 1961).

Placement of females into different reproductive classifications is a technique that has been used to compare the physiological female age of moths captured in traps to oviposition occurrence (Nel, 1940; Showers et al., 1974; and Myers, 1976). A reproductive classification of the codling moth, *Laspeyresia pomonella*, was based on the spermatophore condition, ovary condition, and fat body presence (Nel, 1940). An ECB reproductive classification was based on the condition of the spermatophores and ovaries (Showers et al., 1974). Myers (1976) based the reproductive classification of the green cloverworm on the amount of eggs and fat material present.

Knowledge of adult longevity is required to determine the age and classification of captured female SWCB. In a laboratory study Rolston (1955) observed that the average adult longevity of both sexes was 5-7 days with some individuals living as long as 10 days. In another study Henderson and Davis (1969) determined that the average male longevity was 4.1 days and the average female longevity was 4.4 days.

Oviposition Rate

Insect oviposition rates have been related to the female reproductive classification. Nel (1940) reported that female codling moths were spent or half-spent individuals when attracted to oviposition traps. Geir (1960) reported that the light trap attracted a significantly younger group of female codling moths than the oviposition trap. At the start of ECB emergence, Deay (1950) found that adults were attracted to light traps one or two days before eggs were found in the fields. Showers et al. (1974) observed that peak oviposition occurred 1-3 days after the inverted light trap captured peak numbers of female ECB that had recently mated.

Field determination of the insect oviposition rates is dependent on the knowledge of oviposition sites. Counting corn earworm eggs on corn silks, Connell (1959) was able to estimate adult abundance. Corn plants in a suitable stage were more susceptible to attack. Corn earworms disperse themselves in a non-random manner concentrating in small corn plots that are in a suitable stage for attack (Snow et al., 1968).

The plant condition can affect the ovipositional preference. Rolston (1955) stated that SWCB preferred succulent green corn over dried-out corn as oviposition sites. The number of SWCB eggs per female averaged between 267 (Rolston, 1955) and 350 (Henderson and Davis, 1969). Virgin-female SWCB oviposited considerably fewer eggs than mated females (Rolston, 1955).

Multiple Mating

A high sex pheromone concentration can act as an aphrodisiac (Chapman, 1971). Mating of noctuid moths appeared to be more related to the total population density than the sex ratio (Vail et al., 1968). Multiple matings have been reported from various Lepidoptera (Shorey, 1964; Pesho, 1961; Vail et al., 1968; Jensen et al., 1974; and Myers, 1976). Feral female ECB mate more than once with 8-43 percent having multiple mating (Pesho, 1961). Shorey (1964) observed that male cabbage loopers mated every night as long as receptive females were available. Rolston (1955) stated that female SWCB mated only once, with 66% mating on the same night of emergence, 30% mating on the following night, and 4% mating on the next night. All males were observed mating on the night of emergence and 47% mating a second time the next night. No males were observed mating a third time.

SWCB females vary in their attractiveness to males. Using sticky traps baited with virgin-female SWCB, Henderson and Davis (1967) determined that 59% of the females began attracting males on the first night of emergence and 32% on the next night. The remaining 9% of the females attracted males on the third night. Langille and Keaster (1973) concluded that mated females were only slightly attractive to feral males.

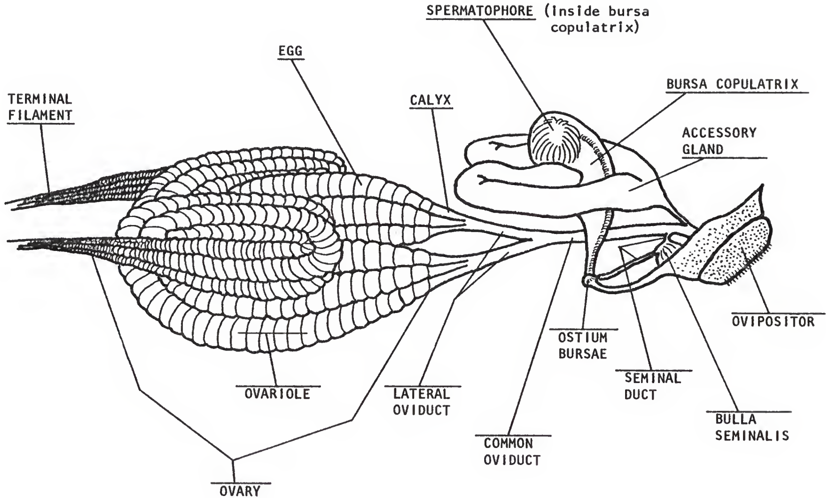
METHODS AND MATERIALS

Female Reproductive Status Study

During the summer of 1977 three standard light traps with calcium cyanide used as a killing agent were located in three corn fields in Stafford County, Kansas. Daily samples of SWCB females from each trap were counted and placed in Kahle's solution for later study. Traps were sampled from July 10 to August 23. The oviposition rate in the field was determined from egg counts that were conducted in Part I.

A laboratory study was conducted using 300 pupae which were sexed and placed in 3.78 l containers. Adults were allowed to emerge. Because major adult emergence occurred during the early evening (Rolston, 1955; and Davis and Henderson, 1967), adults were paired in mating cages (Kira et al., 1969) at 9:00 P.M. Using a completely randomized design, 26-31 replicates of paired adults were placed in 1 of 6 time intervals (0, 24, 48, 72, 96, and 120 h). At the completion of each time interval, females were removed and dissected. The presence and the condition of the spermatophore within the bursa copulatrix (fig. 14) was examined. To determine the oviposition rate all eggs oviposited on the mating cage were counted when the females were removed. Criteria, viz., spermatophore presence, shape, and color, that was used to determine the female reproductive classification of the captured females during the summer, was developed from the

Figure 14. Female SWCB reproductive system showing the location of the spermatophore and bursa copulatrix.


SPERMATOPHORE (inside bursa copulatrix)
EGG
BURSA COPULATRIX
TERMINAL FILAMENT
CALYX
ACCESSORY GLAND
OVIPOSITOR
OSTIUM BURSAE
SEMINAL DUCT
OVARIOLE
LATERAL OVIDUCT
BULLA SEMINALIS
COMMON OVIDUCT
OVARY

laboratory study. Female reproductive classes were (1) females unmated, (2) females mated, spermatophore corpus full, round, and white, (3) females mated, spermatophore partly depleted of sperm, signified by decreased size, invaginations, and yellow coloration, and (4) females mated, spermatophore corpus collapsed and apparently depleted of sperm. All field-collected females were placed in one of the four classifications. Females captured between July 15 and 22 were also observed for multiple mating occurrence.

RESULTS AND DISCUSSION

Female Reproductive Status

During 1977 ca. 6,000 female SWCB were captured and dissected to determine their reproductive classification (table 10). Catches of class 1 and 2 females were very low, while catches of class 3 and 4 were high and approximately equal. Generally, female Lepidoptera are inactive during mating, except for secretion of a sex pheromone that attracts males (Chapman, 1971). Later, during oviposition, females actively seek oviposition sites. Because the percentage of class 1 and 2 females was low in the light trap catches, flight activity was probably low the first night after emergence when mating is believed to occur. Langille and Keaster (1973) observed female SWCB emerging from corn plants and mating later during the same evening. They also observed that virgin females were much more attractive to SWCB males than mated females. Because so few virgin females (class 1) were captured by the light trap, the trap bias for male capture (Part I) cannot be explained by the presence of virgin-female SWCB.

A laboratory study was conducted to determine the length of time that SWCB females remained in each reproductive class and their ovipositional rate (table 11). At the beginning of the study (0 h) females had not mated, so 100% were in class 1. Physical changes to the spermatophore of mated females

Table 10. Total number and % total females in each reproductive class captured in standard light traps between July 9 and August 23, 1977.

Class	No. Females	% Total
1	16	0.27
2	234	3.93
3	2737	46.01
4	2962	49.79
Total	5949	

Table 11. Female SWCB reproductive classification and average percentage of total eggs oviposited by mated females during each time interval.

Time (hr.)	Class % 1	2	3	4	Average % Total Eggs
0	100.0	0.00	0.00	0.00	0.00
24	31.03	68.97	0.00	0.00	0.8
48	11.11	11.11	74.07	3.70	41.4
72	24.14	0.00	58.62	17.24	38.5
96	13.04	0.00	17.39	69.57	19.3
120	22.22	0.00	14.81	62.96	0.0

coincided with mating and ovipositional activities. During the first 24-h interval, mating occurred and the majority of the females entered class 2. Ovipositional activity of class 2 females was slight and females did not actively seek oviposition sites. The presence of class 2 SWCB females was an excellent indicator of recent mating. Major ovipositional activity occurred during the 48 and 72-h intervals with ca. 40% of the eggs laid on each night. At this time the majority of the females were in class 3. Between the 24 and 48-h intervals there was a reduction in the frequency of class 2 females. During the 96-h interval the oviposition rate decreased to ca. 20% and the majority of the females were in class 4. During the last interval (120 h) no new eggs were oviposited and no change was observed in the spermatophore condition from the previous interval (96 h).

In the laboratory the percentage of class 1 females was fairly high throughout the study (table 11). However, unmated females in the field were rarely captured in light traps (table 10). Sparks (1963) observed that ECB required decreasing light intensity, falling temperature, and high RH for successful mating in the laboratory. Optimum conditions for the SWCB mating are not known and probably were not maintained during the mating study. This probably contributed to the high incidence of unmated females. Additionally, the time of pairing was a problem. Adults were paired between 8:00 and 9:00 P.M. which meant that adults emerging after 9:00 P.M. were not paired until the following evening.

Because the average percentages of class 3 and 4 females captured in light traps were higher than the percentages of class 1 and 2 females, the light trap was assumed biased for the capture of older females. The relative female age was developed to determine the female sample age. The relative age was derived from the average age of mated females (class 2 - 1.11 days, class 3 - 2.87 days, and class 4 - 4.26 days) and from the proportion of each class during any sample period, and where:

$$\text{Average Relative Age of Female Pop.} =$$

$$\{\sum \text{Proportion of Each Class (Avg. Age of Each Class)}\} \div 100.$$

The relative age of all captured females (table 10) was 3.49 days. Between 72 and 96 h (3.49 days) in the laboratory ca. 80-100% of the total eggs had been oviposited (table 11). Thus, the majority of the females collected from the field were several days old and had depleted egg compliments at the time of capture.

During the major flight period (July 9-25) there was a general decrease in the proportions of class 2 and 3 females, and an increase in the proportion of class 4 females (table 12). This reflected a young adult population at the beginning of the first-generation flight that increased in relative age. On July 10 the relative female age was low (2.62 days), but on July 24 was substantially higher (3.90 days).

During the summer of 1977 SWCB oviposition rate was estimated in the field (Part I). The relative female age

Table 12. Female reproductive classification of captured females and the average relative age of females captured during the major flight period (July 9 - 25, 1977).

Date (July)	Class (%) 2	3	4	Average Relative Age (days)
9	16.7	66.7	16.0	2.78
10	14.3	76.6	6.1	2.62
11	12.2	43.3	44.4	3.27
12	13.3	52.8	32.5	3.05
13	3.4	67.2	29.3	3.21
14	3.5	42.9	53.6	3.55
15	1.8	60.4	37.7	3.36
16	1.8	51.1	47.0	3.49
17	1.7	44.9	53.4	3.58
18	3.9	43.7	52.4	3.53
19	4.5	41.4	54.1	3.54
20	2.1	48.9	49.0	3.51
21	4.5	53.0	42.5	3.38
22	4.8	45.6	52.7	3.61
23	0.6	33.7	65.7	3.77
24	0.0	26.5	73.5	3.90
25	0.6	30.8	68.6	3.81

of all captured females was ca. 3.5 days and indicated that most of the females had partly and fully depleted egg compliments. This could reasonably explain the peak oviposition period occurring two days prior to the peak female capture (Part I).

Multiple Mating Occurrence

Rolston (1955) observed that SWCB males mated more than once with ca. 50% mating twice. However, he observed no females mating more than once. Between July 15 and 22, 1977, ca. 3,000 SWCB females were dissected to determine the occurrence of multiple mating (table 13). Female SWCB (40.50%) mated more than once; 32.25% had two spermatophores, 8.22% had three spermatophores, and 0.03% had four spermatophores. Because the SWCB sex ratio was estimated as 1:1 (Part I), the percentage of females mating more than once agreed with Rolston's observation that ca. 50% of the males mated twice. Females probably mated only once during a single night. A multiple mated female had spermatophores in various stages of depletion, except class 4 females. All spermatophores of class 4 females were fully depleted. However, spermatophores of class 2 and 3 females had only the most recently deposited spermatophore in that class. All other spermatophores were depleted and appeared as if they were attached to the most recently deposited spermatophore.

Table 13. Mating frequency of female SWCB during the peak 1st generation flight activity period, July 15-22, 1977.

# Matings	# Females	Mating Frequency (%)
0	2	0.07
1	1993	59.43
Multiple	1441	40.50
2	1149	32.25
3	296	8.22
4	1	0.03

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SOUTHWESTERN CORN BORER

FLIGHT AND MATING ACTIVITY

by

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AN ABSTRACT OF A MASTER'S THESIS

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During 1976 and 1977 the major flight period of the first-generation southwestern corn borer (SWCB), Diatraea grandiosella Dyar, lasted ca. two weeks. The 1977 peak flight period occurred ca. two weeks earlier than 1976. The 1977 peak flight occurred during the new moon phase, while the 1976 peak flight occurred during the full moon. During 1977 moth catches were 638% greater than 1976 catches. However, field infestations of second-generation larvae were ca. equal for both 1976 and 1977. Thus, the high flight activity during 1977 reflected the influence of the moon phase and not higher SWCB populations. During either 1976 or 1977 fields that had higher moth activity in comparison to other fields that same season also had higher infestations of second-generation larvae.

Female flight activity was the greatest in the lower portion of the corn plant. Their flight was not greatly affected by corn height. However, more males were captured in short corn than in tall corn.

SWCB mating activity occurred between 1:00 and 2:00 A.M., when significantly ($P < 0.05$) high male and low female flight activity occurred. The major ovipositional period was between 3:00 and 5:00 A.M., when female activity was significantly ($P < 0.05$) high.

During 1976 water pan traps, sticky traps of nine different colors, inverted light traps, and standard light traps were used to capture adults. Only standard light traps effectively trapped SWCB.

During 1977 water pan traps baited with virgin-female SWCB, orange water pan traps, modified inverted light traps, and standard light traps were used to capture SWCB. All traps, except orange water pan traps, effectively captured adults. There was a definite lack of synchrony between light trap catches and baited water pan trap catches. Water pans captured more males at the beginning of the first-generation flight period. As SWCB populations increased, there was greater competition for the males by feral females. This resulted in lower catches in the baited water pan traps. Inverted light traps captured fewer moths than standard light traps. However, during the major flight period there was a high fidelity to the population trend determined by the standard light trap. During low levels of flight activity, inverted light traps did not effectively capture adults.

Egg masses were randomly dispersed in the corn field, while eggs had an aggregated dispersion pattern. This probably resulted from egg masses having 1-7 eggs/mass.

During 1977 the peak ovipositional period occurred two days before the peak female capture in the standard light trap. All captured females were dissected and the condition of the most recently deposited spermatophore was observed. Females were placed in one of four reproductive classes (1-females unmated; 2-females recently mated, spermatophore full, round, and white; 3-females mated, spermatophore invaginated, partially depleted of sperm, and yellow; and 4-females mated, spermatophore collapsed, assumed depleted of sperm). During

the night of adult emergence, mating was the primary activity. Major ovipositional activity occurred during the second and third nights. The majority of the captured females were in classes 3 and 4, and their corresponding relative age was ca. 3.5 days. Thus, females were several days old and had depleted egg complements at the time of capture. Multiple female matings were common occurrences. Ca. 40% of the females captured between July 15 and 22 mated more than once.